ENVIRONMENTAL IMPACTS - NATIVE FLORA AND FAUNA

One of the most serious potential impacts of geothermal energy development in Hawaii is the disruption of native forests. While air pollution and groundwater impacts of geothermal development may be substantially avoided by requiring full control technologies, impacts on native forest ecosystems may only be avoided through careful siting (EPA, 1978). Siting to avoid damage to biologically valuable forest can prevent both degradation of the forest due to invasion of weed species and disturbance of native bird species due to human activity and noise.

Native forests are particularly vulnerable to invasion by exotic species along roadways or other cleared areas (Carlquist, 1970). Once such an invasion begins, native forest is gradually altered, and non-native species, which initially invaded along relatively narrow corridors, spread and multiply (Corn, 1984). Major geothermal development, with an attendant network of roads and construction corridors, may be expected to dissect and eventually degrade undisturbed native forest by opening it to invasion by weedy species.

Geothermal development may also be expected to have negative impact on native forest birds, including many which are endangered. Construction noise and human activity are factors which favor urban nuisance species over native forest species (Berger, 1972). It is therefore important to consider the habitat of native bird species, particularly those which are endangered, in assessing the impact of geothermal energy development. Any development within the habitat of native birds will have much greater environmental impact than development outside of native bird habitat. For endangered bird species, such environmental impacts could be critical.

In selecting areas in which geothermal development will (have) the least environmental impact, it is therefore useful to assess both forest quality and native bird habitat. Those areas with mature native forest and significant native bird habitat will tend to be the most environmentally important, while those without native bird habitat and with less intact forest will be areas in which development would have

substantially less environmental impact. Because of the broad scope of the present study, a detailed analysis of all resource areas for these qualities was impossible. Instead, indicators were used to distinguish, on a broad scale, areas of high and low potential environmental impact. For the present assessment, two indicators have been chosen, one of native habitat importance and one of forest quality.

The indicator chosen to depict the value of an area to native fauna is the presence of endangered species. While under some circumstances a simple survey for endangered species is an unacceptably superficial form of environmental assessment, in the present situation the presence of endangered species correlates quite well with the value of the area to native fauna in general.

Relative value of native forest has been assessed using a categorization system developed by the University of Hawaii Environmental Center based on forest type mapping done by the United States Fish and Wildlife Service (Jacobi, 1983). This system indicates areas in which geothermal development would have the greatest impact on native forest, areas in which geothermal development would have little or no impact on valuable native forest, and areas in which the impact of geothermal development on native forest is uncertain.

Map overlays have been prepared which illustrate the distribution and intersection of essential habitat and forest quality factors. The greatest potential for environmental impact exists where valuable forest and endangered species habitat overlap. Areas with low quality forest and no endangered species habitat may be expected to be among those least vulnerable to impact from geothermal development.

METHODS

For the present assessment, endangered species habitat was considered present wherever essential habitat outlined in an approved Endangered Species Recovery Plan existed. Endangered Species Recovery Plans are plans of action for restoring the population of a species pursuant to its listing as endangered by the Secretary of the Interior. Recovery plans are drafted by teams of wildlife experts from both state and federal agencies, and represent estimates of the range

and life requirements of endangered species by the foremost experts in the field. Essential habitat outlined in an Endangered Species Recovery Plan is therefore almost without exception the most authoritative estimate of the actual habitat for a particular endangered species. Where no essential habitat has been designated, distribution was determined from population surveys conducted by the U.S. Fish and Wildlife Service (USFWS) or other available information (Scott, 1984). Essential habitats have been defined for all endangered forest birds and the Hawaiian Crow ('Alala) on the island of Hawaii and for the Nene on both Maui and the Big Island. Essential habitat has not been determined for the endangered Maui forest birds, and therefore U.S. Fish and Wildlife Service population counts were used to determine habitat boundaries for these species.

The potential for environmental impact on the flora of the resource areas was assessed using a forest categorization system based on USFWS vegetation type mapping. The USFWS system incorporates information on extent of canopy cover, height of canopy, understory composition, and vegetation association type (Jacobi, 1983). Vegetation information has been assembled and mapped by USFWS using this system for large portions of four of the five main Hawaiian islands, including Maui and Hawaii. Information in this form was available to the present study for all or portions of each of the resource areas. Areas not covered were lower Hana, lower Makena, Kilauea S.W. Rift, and Lower Puna. In these areas aerial photo interpretation was used to estimate vegetation type, and in high resource potential areas this aerial interpretation was verified on the ground from readily accessible roadways wherever possible. Lack of access routes made ground verification for the Kilauea S.W. Rift site impractical. The boundaries delineated on the aerial photographs were transferred to orthophoto quadrangles and assigned a vegetation type code following the USFWS system (Jacobi, 1983). Vegetation type data was then ranked according to potential for impact from geothermal development into one of three categories described below.

FLORA AND FAUNA

Flora

Vegetation type data from USFWS mapping or the present study were abstracted into a simplified, three category impact sensitivity classification system (see appendix B). The three categories of this system, which was developed by the University of Hawaii Environmental Center, and based on the assumption that undisturbed, closed canopy forest would be most susceptible to disruption due to geothermal development, are as follows:

CATEGORY 1 - Exceptional native forest; closed canopy, over 90% native cover

CATEGORY 2 - Mature native forest; over 75% native canopy

CATEGORY 2A - Native scrub or low forest

CATEGORY 3 - Cleared land; non-native forest; bare ground or lava

In this system, Category 1 forests are presumed to be areas in which geothermal development would unquestionably result in environmental impact, and Category 3 lands presumed to be areas in which geothermal development would have little or no impact. Category 1 forest is vulnerable because of its high native composition, which indicates that it is virtually undisturbed, and because of its closed canopy, which indicates that any development activity would result in changes in forest structure. Category 3 lands are assumed to be of little biological value owing to high degrees of disturbance or low percentage of ground cover. Category 2 is comprised of areas which did not meet the rigorous standards of category 1, but are not so heavily disturbed or sparsely vegetated that it can be assumed that development would not result in environmental impact. Category 2A ((a subset of Category 2)) represents areas in which the vegetation is predominantly native, but the tree layer is low and scattered and does not warrant the designation of forest. In wet forests, Category 2A vegetation is a sign of disturbance, but in dry regimes, particularly at altitude or along the coast, it is a healthy native ecotype. Both

Category 2 and 2A are classifications which convey that additional information is needed before it can be assumed that geothermal development would have little environmental impact.

The additional information needed to assess the biologic value of Category 2 forest pertains to forest diversity and the presence of rare plants. These factors were not included in the present assessment because this information is not available in any comprehensive form on such a broad scale. Because of these limitations of information availability, it is difficult to arrive at an objective classification for potential for impact by geothermal development for many forest types. There are unquestionably many excellent forest areas that have been placed in Category 2 because they fell just short of 90% native composition. There are equally certainly areas assigned Category 2 which are of little biological interest. Within these extremes, the majority of Category 2 forests are areas for which the USFWS vegetation type code tells only a part of the story, and diversity and rare plant information is required to discern the exact value and vulnerability to disturbance of the area. In the absence of a compelling reason to develop these areas, a reasonable assumption is that they are valuable and should not be disturbed. Where there is compelling reason to consider development, field reconnaissance of individual areas will be required to determine what, if any, level of environmental impact would result from development. Similar considerations apply to Category 2A areas. Vegetation types are assigned to Category 2A based on growth form, not biological value or environmental impact considerations. However, it may be worthwhile to emphasize that in wet areas at intermediate elevations, Category 2A usually represents a disturbed area or recent lava flow.

In summary, Category 1 areas are those in which substantial environmental impact can be expected to result from geothermal development, Category 2 and 2A areas are those in which geothermal development should be assumed to result in environmental impact in the absence of additional information, and Category 3 areas are those in which geothermal development may be expected to have little or no environmental impact.

Clearly the environmental advantage lies in developing within Category 3 areas. However, it is worthwhile to note that development in Category 3 areas may result in environmental impact, especially on native forest birds, if development is immediately adjacent to Category 1 or 2 areas or endangered species habitat and in close enough proximity for noise or pollution to carry to the forest.

Rare Plants

The presence of rare plants greatly increases the biological value of a site, and while this factor is not incorporated in the current categorization system, it must be considered in assessing the sensitivity of an area to environmental impact. Of Hawaii's seven plant species which are formally listed as endangered, only one, the Hawaiian vetch (Vicia menziesii) is found within the resource areas. However, Hawaii has numerous rare plants, over 800 of which have been proposed for listing as endangered. Undoubtedly many of these candidate species may be found within the resource areas. Currently available information does not permit a comprehensive inventory of these species and their location, and therefore has not been addressed in this study. Protection of rare plant species should be undertaken on a project-by-project basis, where botanical surveys of specific areas being considered for development are possible. The forest categories presented in this study do not relate to endangered plant species presence. It should not be assumed that Category 3 areas will contain no rare plant individuals. Isolated rare native species are not uncommonly found in disturbed, non-native surroundings. Such individuals should be identified and protected, but the scope of the present study precluded such detailed analysis. Areas with high concentrations of rare plants are biologically valuable, and the presence of rare plants is one criteria which should be used in determining the potential impact of geothermal development in Category 2 areas. For example, the Category 2 forests in the southwest quarter of the Mauna Loa East Rift area are the home range of Vicia menziesii and should therefore be considered very sensitive to environmental impacts, despite the fact that the forest type alone does

not warrant ranking them in Category 1. Other areas such as this definitely exist within Category 2, and this is one reason why it is important to more completely characterize these areas before their sensitivity to impact is assigned.

Fauna

Forest birds found in the resource areas include the I'iwi, Apapane, Elepaio, and others. The specific native forest birds present at a site are not as important as the relative value of the area as native bird habitat in general. Most native birds share habitat to some degree, and it is this characteristic which permits use of the existence of endangered bird habitat as an index of overall native bird habitat value. Because the list of native birds in the resource areas is long, discussion here will focus only on the endangered fauna found in the resource areas.

Federally designated threatened or endangered fauna within the resource areas include seven forest bird species, two seabird species, the Nene, the Hawaiian Hawk (Io) and Crow ('Alala), and Hawaii's only resident mammal, the Hawaiian Hoary Bat. These species and their treatment in the resource area overlays are outlined below.

'Alala (Corvus tropicus) - One of the most critically endangered species in the United States. Population estimate 10-50 birds in the wild. Last field census reported 7 birds. Essential habitat identified, intersects majority of Hualalai resource area and flanks Kahuku Ranch resource areas (DLNR, 1984).

Hawaii Forest Birds - Includes the Hawaii Creeper (Loxops maculatus mana), Hawaii 'Akepa (Loxops coccineus coccineus), Akiapola'au (Hemignathus wilsoni), and 'O'u (Psittirostra psittacea). All are moderately endangered, with populations in the high 100's or above, except the 'O'u, which is relatively rare and has a much smaller population. Essential habitat common to all four species has been identified, and intersects all of the East Mauna Loa Rift area, most of Hualalai and Upper Puna, and flanks Kahuku Ranch (USFWS, 1982).

Maui Forest Birds - Includes Crested Honeycreeper (Palmeria dolei), Maui 'Akepa (Loxops coccineus), Maui Parrotbill (Pseudonestor xanthoph). Essential habitat not yet identified. Distribution determined by USFWS, intersects upper Hana (Scott, 1984).

Nene (Branta sandvicensis) - Moderately endangered, maintained by

captive breeding. Essential habitat identified, intersects all of East Mauna Loa Rift, most of Hualalai, and the upper elevations of Kahuku Ranch (USFWS, 1983). An upland bird adapted to sparse vegetation, the Nene may be less sensitive to the presence of geothermal development than other native birds.

Hawaiian Hawk (Buteo solitarius) - Relatively common over a wide range. No essential habitat established. Known nesting sites within resource areas lie mainly in Lower Puna and East Mauna Loa Rift, but nesting observations are far from exhaustive and lie mainly along roadways and other accessible areas (Griffin, 1984).

Hawaiian Dark-Rumped Petrel (Pterodroma phaeopygia sanwichensis) - Primary nesting colonies on Maui, outside of resource areas. Also observed within Napau Crater in Volcanoes National Park (USFWS, 1983).

Hawaiian Hoary Bat (Lasiurus cinereus semotus) - A poorly characterized species (Kepler and Scott, 1980). No known roosting sites within resource areas. Most frequently observed in non-native vegetation. Impact of development on foraging habitat uncertain, possibly minimal.

Newell's Manx Shearwater (Puffinu puffinus newelli) - Classified as threatened. No known nesting colonies within resource areas. May occasion Upper Puna and East Mauna Loa Rift (Jacobi, 1984). Impact of development uncertain, may be minimal.

Invertebrates

Rare invertebrates known to exist in the resource areas include scientifically important fruit flies (giant Drosophola spp), tree snails (Particulina spp), and special cave-adapted fauna residing in lava tubes. The giant Drosophola species, focal point of important genetic research, are found in the Mauna Loa East Rift and Hualalai areas, and at upper elevations at Hana and Kahuku Ranch (Carson, 1984). Tree and land snails, many of which, like other Hawaiian invertebrates, are found nowhere else in the world, are associated primarily with native forest and probably exist in all resource areas. Cave-adapted fauna might be found in lava tubes underlying any resource area, but are known to exist in Mauna Loa East Rift and Kilauea East Rift. These lava tube ecosystems are dependent on intact penetrating ohia root systems for their moisture supply, and are vulnerable to any development which results in forest clearing. While invertebrate species often receive less attention than vertebrate

fauna, they comprise an important part of native ecosystems. Impacts on these species may be largely avoided by avoiding siting in native forest areas.

RESOURCE AREA SUMMARIES

Hualalai

An upper elevation site receiving moderate to low rainfall, Hualalai is characterized by vegetation types ranging from forest to scrub and contains extensive endangered species habitat. This area contains some Category 1 forest (but is dominated by) Category 2 forest of a variety of types. Tree species represented in this area include koa (Acacia koa), mamane (Sophora chrysophylla), and ohia (Metrosideros polymorpha). Endangered birds found in the area include the 'Alala, Hawaii Creeper, 'Akepa, and Nene. Because virtually the entire area is endangered bird habitat, development in almost any portion of this area would result in considerable environmental impact.

Kahuku Ranch

The Kahuku Ranch area spans a broad range of elevation and contains vegetation characteristic of both intermediate and upper elevations. Rainfall in this area is generally low. The area is flanked by endangered species habitat for 4 species and Nene essential habitat traverses its upper reaches. Forest types are predominently 2 or 2A, with 2A in this region representing healthy native scrub. The area is also characterized by substantial barren area, areas which might support geothermal development with little environmental detriment. However, air quality and noise impacts should be carefully considered for any of these areas due to the proximity of endangered species habitat.

Mauna Loa East Rift

This area receives low to moderate rainfall and is remarkable for its abundance of Category 1 forest and endangered species habitat. The entire area falls within the essential habitat of endangered species, including all four of the island's endangered forest birds and the Nene. This area is of high biological value throughout and major

geothermal development in virtually any sector of this area would result in substantial environmental impact.

Kilauea Southwest Rift

This area is poorly characterized biologically. It was not included in USFWS vegetation mapping and seems to be of limited research interest. The area is generally disturbed, with some pockets of native scrub along the coast and near the boundary of the national park. These areas are difficult or impossible to distinguish through aerial interpretation, so their exact extent is unknown. However, the area is primarily of little biological significance and contains no endangered species habitat. Development in most portions of this area outside of the National Park would probably result in little environmental impact.

Kilauea Upper East Rift

This area is characterized by recent lava flows on older substrate. The area is relatively wet and supports closed ohia-tree fern forest with a transition to open forest and scrub at lower elevations. Essential endangered species habitat is found in the area, closely associated with the closed forest. Recent lava flows in the area are Category 3 lands, but geothermal development in these areas would require access through and exist in close proximity to Category 1 forest and essential habitat, and therefore air quality and noise impacts should be carefully considered. Due to the presence of Category 1 forest and endangered species habitat, development outside the recent lava flows would result in considerable environmental impact.

Kilauea Lower East Rift

This area is similar in rainfall to Kilauea Upper East Rift over much of its area, but average temperature is higher. Rainfall declines along the coast to the south, and mesic and dry regimes are found in this area. There is no endangered species essential habitat in Lower Puna and the majority of land in the area is current or reverted agricultural acreage falling into Category 3 with few exceptions, the region is of little biological importance (DLNR, 1979, 1981). This area

seems to have high potential for geothermal development without environmental impact, and is more accessible than the Southwest Rift. It was therefore surveyed as part of this assessment. A detailed account of this area and its forest types are appended to this report.

Hana

This area is extremely wet in its upper reaches, supporting numerous small bogs. Forest in the upper portion of this area is also exceptional, falling uniformly into Category 1 above 3,000 ft. and supporting between 1 and 3 species of endangered forest birds. Below 3,000 ft. the forest is more disturbed, gradually blending into Category 2. Below 1,000 ft., forest gives way to pastureland with occasional forested areas. Geothermal development would be likely to have little impact on native forest or birds in most sections of this area below the 1,000-foot contour.

Makena

This is a relatively dry area which ranges in elevation from sea level to over 7,000 ft. The predominant vegetation type, as determined from aerial interpretation only, is native scrub. Some exotic tree plantings are present within the area, as well as substantial areas of pastureland, the precise extent of which is difficult to determine from aerial interpretation. The lower portions of the area are barren lava with isolated pockets of excellent native forest (Medieros, 1984). There is no endangered species habitat in this area. The middle elevations of this area contain some very valuable, although disturbed, dry native forest. Heavily grazed portions of this area would have the potential for geothermal development with little environmental impact, but the exact boundaries of grazing could not be determined within the limitations of this study.

SUMMARY

On the island of Hawaii, resource areas may be grouped into three classes according to potential for environmental impact:

High - Mauna Loa East Rift, Hualalai, Kilauea Upper East Rift

Mixed - Kahuku Ranch

Low - Kilauea Southwest Rift, Kilauea Lower East Rift

On Maui, both resource areas fall into the "mixed" category, with areas with potential for low environmental impact being Hana below the 1,000 ft. contour and the heavily grazed areas of Makena.

APPENDIX A
Kilauea Lower East Rift Zone

The East Rift Zone of Kilauea Volcano stretches 28 miles east-northeast from just south of Kilauea Caldera to Cape Kumukahi near Kapoho, and then beyond undersea for 70 miles (MacDonald and Abbott, 1979). The area included in this discussion is the lower portion of the rift east of Hawaii Volcanoes National Park and south and east of Puna Forest Reserve (Pahoa South and Kapoho Quadrangles and portions of Kalapana and Pahoa North). Elevations within the study area range from 1400 feet east of the Puna Forest Reserve to almost sea level along the coast.

The climate along the lower East Rift and south to the coast is generally wet and warm. Mean annual rainfall ranges from almost 150 inches near Pahoa to 75 inches at Kalapana on the coast. Precipitation is moderately seasonal; summer months are somewhat drier than winter months. Mean annual temperature varies from below 70°F above Pahoa to more than 72°F along the coast (DLNR, 1970).

As Kilauea's East Rift is a geologically active region, much of the substrate here is composed of bare or sparsely vegetated recent flows. The on-going eruption of Puu O near the National Park boundary has produced flows in two directions; northeast into Kahau'alea and the Puna Forest Reserve, and southeast into Royal Gardens Subdivision and upper Kapa'ahu. Other notable historic flows in the lower East Rift Zone are the 1955 series of flows near Kapoho (Kii) and from above the Pahoa-Kalapana Road to the coast near Kehena, and the Kapoho flow of 1960 from Kapoho to Cape Kumakahi. Most soils of the lower East Rift (apart from recent flows and cinder cones) are either histosols, composed of a thin layer of organic material over rock, or inceptisols, formed from volcanic ash.

Vegetation of the lower East Rift cannot be simply characterized. Before human occupation most of this area was probably covered by closed lowland wet forest dominated by 'ohi'a (Metrosideros polymorpha), hala (Pandanus sp.), and lama (Diospyros ferrea) near

the coast grading into an 'ohi'a-lama forest with other native trees (Psychotria hawaiiensi, Xylosma hawaiiense, Tetraplasandra hawaiiensis), iie'ie (Freycinetia arborea), and tree ferns (Cibotium spp.) at higher elevations (around 800 ft.). Another vegetation type which undoubtedly was and still is prominent in the lower East Rift is open to scattered, low to moderate-stature 'ohi'a scrub with uluhe (Dicranopteris spp.), native shrubs, and 'uki (Machaerina mariscoides).

Remnants of these native vegetation types are still found on Kilauea's lower East Rift, but many forests and woodlands here have been disturbed to some degree or cleared for agriculture, towns, and subdivisions. Large tracts of land in this area are planted in sugar cane, papaya, and to a lesser extent, macadamia nuts. In addition to these cultivated fields, much old agricultural land has been abandoned and has a cover of weedy species of exotic trees, grasses, and shrubs. Apart from agricultural lands, several subdivisions have been developed in lower Puna, resulting in large parcels of forest and scrub cut by roads and clearings. Clearing and road-cutting in the East Rift has been followed by the invasion of forests and woodland by exotic plants, which are the major factor of disturbance in this area. Some of the most noxious of these exotic weeds are Malabar melastome (Melastoma malabathricum), christmasberry (Schinus terebinthifolius), waiawi (Psidium cattleianum), guava (P. guajava), thimbleberry (Rubus rosaefolius), melochia (Melochia umbellata), lantana (Lantana camara), California grass (Brachiaria mutica), Molasses grass (Melinis minutiflora), and broomsedge (Andropogon virginicus). Feral pigs are another major factor of disturbance in the upper forests of this region.

The most undisturbed and diverse remnants of vegetation noted during this survey were three areas in the Pahoa South Quadrangle. One of these is the closed 'ohi'a-lama forest of Keauohana Forest Reserve. The canopy of this forest is intact and the secondary tree layer is rich, containing two candidate endangered tree species ('ahakea-Bobea timonioides and 'ohe-Tetraplasandra hawaiiensis), as well as diversity of other native trees such as opuhe (Urera

sandvicensis), maua (Xylosma hawaiiense), mamaki (Pipturus sp), kopiko (Psychotria hawaiiensis), and others. Although the understory of this forest contains exotic plants, it also has many native components such as tree ferns and native shrubs.

The second most botanically rich area is in the southeast corner of Leilani Estates and the northern part of Malama-Ki Forest Reserve (ea. 700 ft). This is also a closed tall 'ohi'a-lama forest with 'ohe trees and tree ferns. The third most interesting area is a small fore above Kama'ili fronting a lobe of the 1955 lava flow at about 200 ft. elevation. This low-elevation 'ohi'a-lama forest is composed almost entirely of native plants and supports a predominantly native understory of ferns and shrubs, including the candidate endangered ko'oko'olau (Bidens skottsbergii).

Several other relatively diverse, mostly native forests were found in the lower East Rift Zone. The most notable of these were in Puulena and Kahawai Craters, on the east side of Nanawale Estates, on the slopes behind the quarry near Kalapana, in the Halepua'a section of Nanawale Forest Reserve, and on relatively recent substrate near Kaimu, Kehena, and Pualaa. These are 'ohi'a-lama or 'ohi'a dominated lowland forests with a predominance of native plants; all but the coastal forests with exposed aa are known to support candidate endangered plant species. In addition to these closed and open forests, several scrub vegetation types dominated by native shrubs and low trees (but lacking uluhe) were observed near the Hawaii Volcanoes National Park boundary past Kalapana, on the coast at the east end of Malama-Ki, and along the coast near Nanawale north of Kapoho and south of Hawaiian Beaches.

As this was a broad-scope brief survey to determine as many vegetation types within the lower East Rift Zone as possible, and not every area differentiated on aerial photographs was ground checked. In particular, closed forests not reached include those on the upland slopes above Kalapana, remnant stands on the rift between Leilani Estates and the Opihikao Road, areas bordering the east side of the Puna Forest Reserve and several coastal areas separated from roads by inhabited parcels near Kehena and Kapoho.

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Appendix B

Criteria for Vegetation Categorization from USFWS Mapping Code*

(1) c3, c2, o3 w/tf, o2 w/tf, o3 if dry or mesic

and

90% or more native species by cover

(2) c o 3, c o 2 and 75% native canopy
(or simply 75% native canopy in non-ohia dominated dry and mesic communities)

(2A) s vs 3 or 2, c o s vs 1, o2 w/mf

and

50% or more native species by cover

(3) Less than 50% native species [3] or)

Less than 50% ground cover [xx]

NOTE: On maps, numbers in parentheses indicate areas which were assessed from aerial interpretation only.

*This system cannot be extrapolated to areas containing extensive dry or mesic forests, and should therefore be used as a categorization system only within the resource areas discussed in this report.